1

Introduction to the Framework

Introduction to the Framework

California is a world leader in science and technology and, as a result, enjoys both prosperity and a wealth of intellectual talent. The nation and the state of California have a history that is rich in innovation and invention. Educators have the opportunity to foster and inspire in students an interest in science; the goal is to have students gain the knowledge and skills necessary for California's workforce to be competitive in the global, information-based economy of the twenty-first century.

The *Science Framework for California Public Schools* is the blueprint for reform of the science curriculum, instruction, professional preparation and development, and instructional materials in California. The framework outlines the implementation of the *Science Content Standards for California Public Schools* (adopted by the State Board of Education in 1998)[1] and connects the learning of science with the fundamental skills of reading, writing, and mathematics. The science standards contain a concise description of what to teach at specific grade levels; this framework extends those guidelines by providing the scientific background and the classroom context.

Glenn T. Seaborg, one of the great scientific minds of this era, defined science as follows: "Science is an organized body of knowledge and a method of proceeding to an extension of this knowledge by hypothesis and experiment."[2] This framework is intended to (1) organize the body of knowledge that students need to learn during their elementary and secondary school years; and (2) illuminate the methods of science that will be used to extend that knowledge during the students' lifetimes.

Although the world will certainly change in ways that can hardly be predicted in the new century, California students will be prepared to meet new challenges if they have received a sound, basic education. This framework outlines the foundation of science knowledge needed by students and the analytical skills that will enable them to advance that knowledge and absorb new discoveries.

Audiences for the Framework

One of the primary audiences for this framework is the teachers who are responsible for implementing the science standards. These teachers are elementary and middle school teachers with multiple-subject credentials, middle and high school teachers with single-subject credentials in science, and those who may be teaching outside their primary area of expertise. The *Science Framework* is designed to provide valuable insights to both novice and expert science teachers.

For designers of science instructional materials, the framework may serve as a guide to the teaching of the science standards and as an example of the scholarly treatment of science that is expected in their materials. Publishers submitting science instructional materials for adoption in the state of California must adhere to a set of rigorous criteria described in this framework. The criteria include careful alignment with and comprehensive coverage of the science standards, good program organization and provisions for assessment, universal access for students with special needs, and instructional planning and support for the teacher.

The organizers of both programs of preservice professional preparation and in-service professional development will find this framework helpful. Skill is needed to teach science well, and training programs for teachers need to be especially mindful of the expectations placed on students.

Scientists and other professionals in the community often seek ways to help improve their local schools, and this framework will be helpful in focusing their efforts on a common set of curricular goals. By providing ideas and resources aligned with grade-level standards, professionals can make sure their outreach efforts and donations to classrooms will be put to best use.

For many high school seniors, commencement is followed shortly thereafter by baccalaureate courses. The *Science Framework* communicates to the science faculty at all California institutions of higher education what they may expect of entering students.

Finally, the parents, guardians, and other caregivers of students will find the *Science Framework* useful as they seek to help children with homework or gain an understanding of what their children are learning in school.

Instructional Materials

One of the best measures that local educational agencies (LEAs) can take is to ensure that all teachers of students in kindergarten through grade eight are provided with materials currently adopted by the State Board of Education (especially in science, mathematics, and reading/language arts) and are trained in their use. Those materials undergo a rigorous review and provide teachers and other instructional staff with guidance and strategies for helping students who are having difficulty.

In choosing instructional materials at the high school level, LEAs need to be guided by the science standards and the evaluation criteria set forth in Chapter 9. An analogy used in the *Reading/Language Arts Framework for California Public Schools* is equally applicable to the teaching of science: "Teachers should not be expected to be the composers of the music as well as the conductors of the orchestra."[3] In addition to basic instructional materials, teachers need to be able to gain access to up-to-date resources in the school library-media center that support the teaching of standards-based science. The resources must be carefully selected to support and enhance the basic instructional materials.

The Challenges in Science Education

Elementary school students often learn much from observing and recording the growth of plants from seeds in the classroom. But are the same students well served if seed planting is a focus of the science curriculum in the next year and the following one as well? The same question may well be asked of any instructional activity. To overcome the challenges in science education, several strategies are recommended:

Prepare Long-Term Plans

Long-term planning of a science curriculum over a span of grades helps students learn new things and develop new skills each year. A standards-based curriculum helps students who move from district to district; they will be more likely to receive a systematic and complete education.

The *Science Content Standards* and the *Science Framework* are designed to ensure that all students have a rich experience in science at every grade level and that curriculum decisions are not made haphazardly. Instructional programs need the content standards to be incorporated at each grade level and should be comprehensive and coherent over a span of grade levels.

Reforming science curriculum, instruction, and instructional materials will be a time-consuming process. To achieve the reform objectives, all educational stakeholders need to adhere to the guidance provided in this framework. The hope is that in the near future teachers will have a much greater degree of certainty about the knowledge and skills the students already possess as they file into the classroom at the beginning of a school year. Less time will be spent on review, and teachers will also have a clear idea of the content their students are expected to master at each grade level and in each branch of science.

Meet the Curricular Demands of Other Core Content Areas

The *Reading/Language Arts Framework* and *Mathematics Framework*[4] explicitly require uninterrupted instructional time in those subjects. In the early elementary grades, students need to receive at least 150 minutes of reading/language arts instruction daily and 50 to 60 minutes of mathematics instruction. At the elementary school level, the pressure to raise the academic performance of students in reading/language arts and mathematics has led some administrators to eliminate or curtail science instruction. This action is not necessary and reflects, in fact, a failure to serve the students. The *Science Framework* helps to organize and focus elementary science instruction, bringing it to a level of efficiency so that it need not be eliminated.

All teachers, particularly those who teach multiple subjects, need to use their instructional time judiciously. One of the key objectives set forth in the *Mathematics Framework* applies equally well to the study of science: “During the great majority of allocated time, students are active participants in the instruction.”[5] In this case *active* means that students are engaged in thinking about science. If the pace of an activity is too fast or too slow, students will not be “on task” for much of the allotted time.

When large blocks of time for science instruction are not feasible, teachers must make use of smaller blocks. For example, an elementary teacher and the class may have a brief but spirited discussion on why plant seeds have different shapes or why the moon looks different each week. For kindergarten through grade three, standards-based science content is now integrated into nonfiction material in the basic reading/language arts reading programs adopted by the State Board of Education. Publishers were given the following mandate in the *2002 K–8 Reading/Language Arts/English Language Development Adoption Criteria:*

> In order to protect language arts instructional time, those K–3 content standards in history–social science and science that lend themselves to instruction during the language arts time period are addressed within the language arts materials, particularly in the selection of expository texts that are read to students, or that students read.[6]

There is no begrudging of the extended time needed for students to master reading, writing, and mathematics, for those are fundamental skills necessary for science. The *Reading/Language Arts Framework* states this principle clearly: "Literacy is the key to becoming an independent learner in all the other disciplines."[7] The *Mathematics Framework* bears a similar message: "The [mathematics] standards focus on essential content for all students and prepare students for the study of advanced mathematics, science and technical careers, and postsecondary study in all content areas."[8]

Despite the aforementioned curricular demands, the science standards should be taught comprehensively during the elementary grades. This challenge can be met with careful planning and implementation.

Set Clear Instructional Objectives

In teaching the science standards, LEAs must have a clear idea of their instructional objectives. Science education is meant to teach, in part, the specific knowledge and skills that will allow students to become literate adults. As John Stuart Mill wrote in 1867:

> It is surely no small part of education to put us in intelligent possession of the most important and most universally interesting facts of the universe, so that the world which surrounds us may not be a sealed book to us, uninteresting because unintelligible.[9]

Science education, however, is more than the learning of interesting facts; it is the building of intellectual strength in a more general sense:

> The scholarly and scientific disciplines won their primacy in traditional programs of education because they represent the most effective methods which . . . have been [devised] through millennia of sustained effort, for liberating and organizing the powers of the human mind.[10]

Science education in kindergarten through grade twelve trains the mind and builds intellectual strength and must not be limited to the lasting facts and skills that can be remembered into adulthood. Science must be taught at a level of rigor and depth that goes well beyond what a typical adult knows. It must be taught "for the sake of science" and not with any particular vocational goal in mind. The study of science disciplines the minds of students; and the benefits of this intellectual training are realized long after schooling, when the details of the science may be forgotten.

Model Scientific Attitudes

Science must be taught in a way that is scholarly yet engaging. That is, an appropriate balance must be maintained between the fun and serious sides of science. A physics teacher might have students build paper airplanes to illustrate the relationship between lift and drag in airflow; but if the activity is not deeply rooted in the content of physics, then the fun of launching paper airplanes displaces the intended lesson. The fun of science may be a way to help students remember important ideas, but it cannot substitute for effective instruction and sustained student effort.

There are certain attitudes about science and scientists that a teacher must foster in students. Scientists are deeply knowledgeable about their fields of study but typically are willing to admit that there is a great deal they do not know. In particular, they welcome new ideas that are supported by evidence. In doing their research good scientists do not attempt to prove that their own hypotheses are correct but that they are incorrect.[11] Though somewhat counterintuitive, this path is the surest one to finding the truth.

Classroom teachers must always provide rational explanations for phenomena, not occultic or magical ones. They need to be honest about what they do not know and be enthusiastic about learning new things along with their students. They must convey to students the idea that there is much to learn and that phenomena not currently understood may be understood in the future. Knowledge in science is cumulative, passed from generation to generation, and refined at every step.

Provide Balanced Instruction

Some of the knowledge of science is best learned by having students read about the subject or hear about it from the teacher; other knowledge is best learned in laboratory or field studies. Direct instruction and investigative activities need to be mutually supportive and synergistic. Instructional materials need to provide teachers with a variety of options for implementation that are based on the science standards.

For example, students might learn about Ohm's law, one of the guiding principles of physics, which states that electrical current decreases proportionately as resistance increases in an electrical circuit operating under a condition of constant voltage. In practice, the principle accounts for why a flashlight with corroded electrical contacts does not give a bright beam, even with fresh batteries. It is a simple relationship, expressed as $V=IR$, and embodied in high school Physics Standard 5.b. In a laboratory exercise, however, students may obtain results that seem to disprove the linear relationship because the resistance of a circuit element varies with temperature. The temperature of the components gradually increases as repeated tests are performed, and the data become skewed.

In the foregoing example, it was not Ohm's law that was wrong but an assumption about the stability of the experimental apparatus. This assumption can be proven by additional experimentation and provides an extraordinary opportunity for students to learn about the scientific method.

Had the students been left to uncover on their own the relationship between current and resistance, their skewed data would not have easily led them to discover Ohm's law. A sensible balance of direct instruction and investigation and a focus on demonstration of scientific principles provide the best science lesson.

Ensure the Safety of Instructional Activities

Safety is always the foremost consideration in the design of demonstrations, hands-on activities, laboratories, and science projects on site or away from school. Teachers need to be familiar with the *Science Safety Handbook for California Public Schools.*[12] It contains specific and useful information relevant to classroom teachers of science. Following safe practices is a legal and moral obligation for administrators, teachers, parents or guardians, and students. Safety needs to be taught. Scientists and engineers in universities and industries are required to follow strict environmental health and safety regulations. Knowing and following safe practices in science are a part of understanding the nature of science and scientific procedures.

Match Instructional Activities with Standards

Teachers need to use instructional materials that are aligned with the *Science Content Standards,* but how do they know when a curriculum or supplemental material is a good match? The State Board of Education establishes content review panels to analyze the science instructional materials submitted for adoption in kindergarten through grade eight. The panels consist of professional scientists and expert teachers of science. Local educational agencies would be well advised to use materials that have passed this stringent test for quality and alignment. The criteria are included in the *Science Framework* (Chapter 9) and may help guide the decisions of school districts and schools when they adopt instructional materials for grades nine through twelve.

In brief, teachers need to use instructional activities or readings that are grounded in science and that provide clear and nonsuperficial lessons. The content must be scientifically accurate, and the breadth and depth of the science standards need to be addressed. Initial teaching sequences must communicate with students in the most straightforward way possible, and expanded teaching used to amplify the students' understanding.[13] The concrete examples, investigative activities, and vocabulary used in instruction need to be unambiguous and chosen to demonstrate the wide range of variation on which scientific concepts can be generalized.

For example, in grade four Standard 2.a is: "Students know plants are the primary source of matter and energy entering most food chains."[14] This standard may be taught by using numerous concrete examples. Mastery of the concept, however, requires that students understand how the concept is generalized. Having learned by explicit instruction that plants are primary producers in deserts, forests, and grasslands, the students must be able to generalize the principle accurately to include other habitats (e.g., salt marshes, lakes, tundra). Although the standard is easily amenable to laboratory and field activities, it cannot be entirely grasped by observation of or contact with nature.

In high school this standard is explored in considerable depth as students come to learn about energy, matter, photosynthesis, and the cycling of organic matter in an ecosystem. Standard 2.a in grade four prepares students to learn more.

Another example of "preteaching" embedded in the science standards is Standard 1.h in grade three: "Students know all matter is made of small particles called atoms, too small to see with the naked eye."[15] The intent of this standard is not to make third-grade students into atomic scientists, but simply to introduce them to a way of thinking that is reinforced in grades five and eight and then taught in greater depth in high school.

This framework is designed to ensure that instructional materials are developed to the intended depth of each standard and that the relationships are made clear among standards across grade levels and within branches of science.

Science and the Environment

Environmental concerns that once received relatively little attention (e.g., invasive species of plants and animals, habitat fragmentation, loss of biodiversity) have suddenly become statewide priorities. Entire fields of scientific inquiry (e.g., conservation biology, landscape ecology, ethnoecology) have arisen to address those concerns. In general, there is an increased sense of the complexity and interconnectedness of environmental issues. The public response to California's environmental challenges has been profound as evidenced by the enactment of Senate Bill 373 (Chapter 926, Statutes of 2001). Senate Bill 373 requires the following topics to be included in this framework:

- Integrated waste management
- Energy conservation
- Water conservation and pollution prevention
- Air resources
- Integrated pest management
- Toxic materials
- Wildlife conservation and forestry

Several science standards address those topics directly; provide students with the foundational skills and knowledge to understand them; or incorporate concepts, principles, and theories of science that are integral to them. The suggestions in this framework include ways of highlighting the topics as follows:

- Students in kindergarten through grade five learn about the characteristics of their environment through their studies of earth, life, and physical sciences. For example, in grade three students learn how environmental changes affect living organisms.
- Students in grades six through eight focus on earth, life, and physical sciences, respectively; and standards at each grade level include the study of ecology and the environment.

- Students in grades nine through twelve expand their knowledge of habitats, biodiversity, and ecosystems associated with the biology/life science content standards. High school earth science standards include the study of energy and its usage as well as topics related to water resources and the geology of California.

The Legislature has declared "that [we have] a moral obligation to understand the world in which [we live] and to protect, enhance, and make the highest use of the land and resources [we hold] in trust for future generations, and that the dignity and worth of the individual requires a quality environment in which [we] can develop the full potentials of [our] spirit and intellect" (*Education Code* Section 8704). Toward that end LEAs and individual schools throughout California are contributing to the betterment of the environment in many ways, including replacing asphalt school grounds with gardens, recycling school waste, exchanging scientific data with the international community through Web sites, and restoring local habitats.

Specific programs of environmental education enhance the learning of science at all grade levels. These programs enhance scientific and critical thinking skills, enabling students to perceive patterns and processes of nature, research environmental issues, and propose reasoned solutions. Environmental education is not advocacy for particular opinions or interests, but it is a means of fostering a comprehensive and critical approach to issues. Students get a personal sense of responsibility for the environment; consequently, schools are tied more closely to the life of the communities they serve.

Guiding Principles

The following principles form the basis of an effective science education program. They address the complexity of the science content and the methods by which science content is best taught. They clearly define the attributes of a quality science curriculum at the elementary, middle, and high school levels.

Effective science programs are based on standards and use standards-based instructional materials.

Comprehensive, standards-based programs are those in which curriculum, instruction, and assessment are aligned with the grade level-specific content standards (kindergarten through grade eight) and the content strands (grades nine through twelve). Students have opportunities to learn foundational skills and knowledge in the elementary and middle grades and to understand concepts, principles, and theories at the high school level. Students use instructional materials that have been adopted by the State Board of Education in kindergarten through grade eight. For grades nine through twelve, students use instructional materials that are determined by local boards of education to be consistent with the science standards and this framework.

A *California Standards Test* in science is now administered at grade five, reflecting the cumulative science standards for grades four and five. Therefore, science instruction must be based on complete programs that cover all the standards at every grade level. The criteria for evaluating K–8 science instructional materials (see Chapter 9) state: "All content Standards as specified at each grade level are supported by topics or concepts, lessons, activities, investigations, examples, and/or illustrations, etc., as appropriate."

At the high school level, the *Science Content Standards* document does not prescribe a single high school curriculum. To allow LEAs and teachers flexibility, the standards for grades nine through twelve are organized as content strands. There is no mandate that a particular content strand be completed in a particular grade. Students enrolled in science courses are expected to master the standards that apply to the curriculum they are studying regardless of the sequence of the content. Students in grades nine through twelve use instructional materials that reflect the *Science Content Standards* and this framework, and LEAs must critically review the standards maps that are now to be provided by publishers of high school instructional materials.[16]

The *California Standards Tests* for grades nine through eleven pertain specifically to the content of the particular science courses in which students are enrolled. The California Department of Education makes blueprints for those tests and sample questions available to the public. Local educational agencies are encouraged to review and improve (as necessary) their high school science programs to achieve the following results:

1. All high school science courses that meet state or local graduation requirements or the entrance requirements of the University of California or The California State University are based on the *Science Content Standards.*
2. Every laboratory science course is based on the content standards and ensures that students master both the content-specific standards and Investigation and Experimentation standards.
3. Every science program ensures that students are prepared to be successful on the *California Standards Tests.*
4. All students take, at a minimum, two years of laboratory science providing fundamental knowledge in at least two of the following content strands: biology/life sciences, chemistry, and physics. Laboratory courses in earth sciences are acceptable if prerequisite courses are required (or provide basic knowledge) in biology, chemistry, or physics.[17]

Effective science programs develop students' command of the academic language of science used in the content standards.

The lessons explicitly teach scientific terms as they are presented in the content standards. New words (e.g., *photosynthesis*) are introduced to reflect students' expanding knowledge, and the definitions of common words (e.g., *table*) are expanded to incorporate specific meanings in science. Developing students' command of the academic language of science must be a part of instruction at all grade levels (kindergarten through grade eight) and in the four content strands (grades nine through twelve). Scientific vocabulary is important in building conceptual understanding. Teachers need to provide explanations of new terms and idioms by using words and examples that are clear and precise.

Effective science programs reflect a balanced, comprehensive approach that includes the teaching of investigation and experimentation skills along with direct instruction and reading.

A balanced, comprehensive approach to science includes the teaching of investigation and experimentation skills along with direct instruction and reading. Investigation and experimentation standards are progressive and need to be taught in a manner integral to the physical, life, and earth sciences as students learn quantitative skills and qualitative observational skills. For example, the metric system is first introduced in grade two, but students use and refine their skill in metric measurement through high school. The methods and skills of scientific inquiry are learned in the context of the key concepts, principles, and theories set forth in the standards. Effective use of limited instructional time is always a major consideration in the design of lessons and courses. Laboratory space and equipment, library access, and resources are essential to support students' academic growth in science.

Effective science programs use multiple instructional strategies and provide students with multiple opportunities to master the content standards.

Multiple instructional strategies, such as direct instruction, teacher modeling and demonstration, and investigation and experimentation, are useful in teaching science and need to be included in instructional materials. Those strategies help teachers capture student interest, provide bridges across content areas, and contribute to an understanding of the nature of science and the methods of scientific inquiry.

Standards for investigation and experimentation are included at each grade level and differ from the other standards in that they do not represent a specific content area. Investigation and experimentation cuts across all content areas, and those standards are intended to be taught in the context of the grade-level content. Hands-on activities may compose up to a maximum of 20 to 25 percent of the science instructional time in kindergarten through grade eight. Instruction is designed and sequenced to provide students with opportunities to reinforce foundational skills and knowledge and to revisit concepts, principles, and theories previously taught. In this way student progress is appropriately monitored.

Effective science programs include continual assessment of students' knowledge and understanding, with appropriate adjustments being made during the academic year.

Effective assessment (on a continuing basis through the academic year) is a key ingredient of standards-based instruction. Teachers assess students' prerequisite knowledge, monitor student progress, and evaluate the degree of mastery of the content called for in the standards. Lessons include embedded unit assessments that provide formative and summative assessments of student progress. Teachers and administrators regularly collaborate to improve science progress by examining the results of *California Standards Tests* in science (both the general test at grade five and the specific tests in grades nine through eleven).

Effective science programs continually engage all students in learning and prepare and motivate students for further instruction in science.

Students who are unable to keep up with the expectations for learning science often lack basic skills in reading comprehension and mathematics. Therefore, students who need extra assistance to achieve grade-level expectations are identified early and receive support. Schools need to use transitional materials that accelerate the students' reading and mathematics achievement to grade level. Advanced learners must not be held back but be encouraged to study science content in greater depth.

Effective science programs use technology to teach students, assess their knowledge, develop information resources, and enhance computer literacy.

Across the nation science in the laboratory setting involves specialized probes, instruments, materials, and computers. Scientists extend their ability to make observations, analyze data, study the scientific literature, and communicate findings through the use of technology. High-performance computing capabilities are used in science to make predictions based on fundamental principles and laws. Technology-based models are used to design and guide experiments, making it possible to eliminate some experiments and to suggest other experiments that previously might not have been considered. Students have the opportunity to use technology and imitate the ways of modern science. Teaching science by using technology is important for preparing students to be scientifically and technologically literate. Assembly Bill 1023 (Chapter 404, Statutes of 1997) requires that newly credentialed teachers demonstrate basic competence in the use of computers in the classroom.

Effective science programs have adequate instructional resources as well as library-media and administrative support.

Standards-based teaching and learning in science demand adequate instructional resources. Local educational agencies and individual school sites need to include science resources as an integral part of the budget. Library-media staff must have science as a priority for resource acquisition and development. Administrators must ensure that funds set aside for the science resources are spent efficiently (e.g., through clear processes and procedures for purchasing and maintenance) and support students' mastery of the content standards. This priority requires planning, coordination, and dedication of space for science resources.

Effective science programs use standards-based connections with other core subjects to reinforce science teaching and learning.

Science instruction provides multiple opportunities to make connections with other content areas. Reading, writing, mathematics, and speaking skills are needed to learn and do science. In self-contained classrooms, teachers incorporate science content in reading, writing, and mathematics as directed in the *Reading–Language Arts Framework* and *Mathematics Framework*. In departmentalized settings (middle and high school levels) science teachers need to include essay assignments and require that students' writing reflect the correct application of English-language conventions, including spelling and grammar.

Organization of the Framework

The *Science Framework* is primarily organized around the *Science Content Standards.* The framework:

- Discusses the nature of science and technology and the methods by which they are advanced (Chapter 2)
- Describes the curriculum content and instructional practices needed for mastery of the standards (Chapters 3, 4, and 5)
- Guides the development of appropriate assessment tools (Chapter 6)
- Suggests specific strategies to promote access to the curriculum for students with special needs (Chapter 7)
- Describes the system of teacher professional development that needs to be in place for effective implementation of the standards (Chapter 8)
- Specifies the requirements for evaluating science instructional resources, including investigative activities, for kindergarten through grade eight (Chapter 9)
- Provides information on pertinent requirements of the California *Education Code* regarding science education in this state (Appendix)

The science standards are embedded in Chapters 3, 4, and 5 and are grade-level specific from kindergarten through grade eight. The standards for grades nine through twelve are organized by strands: physics, chemistry, biology/life sciences, and earth sciences.

Notes

1. *Science Content Standards for California Public Schools, Kindergarten Through Grade Twelve.* Sacramento: California Department of Education, 2000.
2. Glenn T. Seaborg, "A Letter to a Young Scientist," in *Gifted Young in Science: Potential Through Performance.* Edited by Paul Brandwein and others. Arlington, Va.: National Science Teachers Association, 1989. The late Dr. Seaborg was chair of the California Academic Standards Commission's Science Committee that created the *Science Content Standards for California Public Schools*.
3. *Reading/Language Arts Framework for California Public Schools, Kindergarten Through Grade Twelve*. Sacramento: California Department of Education, 1999, p. 2.
4. *Mathematics Framework for California Public Schools, Kindergarten Through Grade Twelve*. Sacramento: California Department of Education, 2000.
5. *Mathematics Framework*, p. 13.
6. These criteria are available on the Web site<*http://www.cde.ca.gov/cfir/rla/2002criteria.pdf*>. Click on Criteria Category 2, third bullet.
7. *Reading/Language Arts Framework,* p. 3.

8. *Mathematics Framework,* p. 18.
9. John Stuart Mill, inaugural address to the University of St. Andrew, quoted in George E. DeBoer, *A History of Ideas in Science Education.* New York: Teachers College Press, 1991, p. 8.
10. Arthur E. Bestor, *Educational Wastelands: The Retreat from Learning in Our Public Schools.* Champaign: University of Illinois Press, 1953. p. 18.
11. J. R. Platt, "Strong Inference," *Science,* Vol. 146 (1964), 347–53.
12. *Science Safety Handbook for California Public Schools.* Sacramento: California Department of Education, 1999.
13. Siegfried Engelmann and Douglas Carnine, *Theory of Instruction: Principles and Applications.* Eugene, Ore.: ADI Press, 1991.
14. *Science Content Standards,* p. 11.
15. Ibid., p. 8.
16. According to *Education Code* Section 60451, standards maps are documents that school districts use in determining the extent to which instructional materials (for pupils in grades nine to twelve, inclusive) are aligned to the content standards adopted by the State Board of Education. Publishers prepare the standards maps using a form created and approved by the State Board of Education.
17. The laboratory science subject requirement for admission to the University of California and (beginning in fall 2003) to The California State University reads as follows: "d. Laboratory Science. Two years required, three recommended. Two years of laboratory science providing fundamental knowledge in at least two of these three disciplines: biology (which includes anatomy, physiology, marine biology, aquatic biology, etc.), chemistry, and physics. Laboratory courses in earth/space sciences are acceptable if they have as prerequisites or provide basic knowledge in biology, chemistry, or physics. The appropriate two years of an approved integrated science program may be used to fulfill this requirement. Not more than one year of ninth-grade laboratory science can be used to meet this requirement."

    Source: University of California Office of the President <*http://www.ucop.edu*> and The California State University <*http://www.calstate.edu*>.